Devising materials experiments students can do at home
INTRODUCTION

Many of our community, lecturers in the disciplines of and relating to Materials Science and Engineering, have expressed interest in simple-to-use guides to support the workshops we run on learning and teaching. As part of our ‘Thematic Groups’ scheme, we have established 12 themes for this special focussed support, each of which is led by a ‘Thematic Group Leader’. During the first two years of the scheme, workshops have been held on these themes and this has enabled the leaders to further explore relevant issues with lecturers and feed the results into this series of booklets.

Learning and teaching is a continuous cycle represented in the diagram below:

We can start at any point around the cycle. If we are in the business of teaching it certainly helps if there is someone to teach! Not such a funny joke in the current climate with reducing numbers of students in technical disciplines. Hence one of our main concerns is how can we approach schools and work with school students to attract them into Materials areas. ‘Attracting Materials Students’ by Cheryl Anderson explores how we can work with schools and the wider community to ensure a diverse and inclusive group of able students on our courses. Once we have a class to teach, what would we like to teach them? The first reaction to such a question is to make a list of topics or knowledge. However, this is only a beginning, and a very limited one. Not only are there are many skills and attitudes that we
would like them to develop, but learning is more complex than simply the what. It also involves the how. ‘Developing Professional Skills’ by John Wilcox explores the approach to empowering students to track their own skills development as they progress. ‘Materials for Engineers’ by Mike Bramhall, ‘Materials Chemistry’ by Stephen Skinner and ‘Environmental Materials’ by Cris Arnold, focus on what we might like to include in a specialised curriculum, for targeted students. The knowledge, skills and attitudes or learning objectives identified for each course must be assessed if we are going to give credit to students for learning what we want them to learn. ‘Assessing Materials Students’ by Lewis Elton gives support to the development of assessments and assignments that do in fact give marks for those things we want to acknowledge, rather than those aspects that are simply easy to assess!

Believe it or not it is only at this stage that we can really consider how we should teach the students to learn these things. We all know about lectures but will we use in addition or instead: tutorials (‘Tutoring Materials’ by Adam Mannis and Shanaka Katuwawala), labs (‘Teaching Materials Lab Classes’ by Caroline Baillie), case studies (‘Teaching Materials Using Case Studies’ by Claire Davis and Elizabeth Wilcock), problem based learning (‘Learning Materials in a Problem Based Course’ by James Busfield and Ton Peijs) or even learning at a distance (‘Learning Materials at a Distance’ by Mark Endean)?

The final stage before we start all over again is to see if we have done what we intended to do. We may have already found out whether, and how effectively, the students learnt what we wanted them to (i.e. if the assessment matched the learning objectives and if our teaching methods suited the students’ learning approaches). If this has not proved to be as ideal a scenario as we would have wished we will need further input to analyse what has happened. ‘Were the course objectives inappropriate?’ ‘Did the students take on surface approaches to learning because of my teaching?’ Ivan Moore’s ‘Evaluating a Materials Course’ will give you the tools of the trade to conduct your own thorough evaluation and enable you to develop an improved course for next year’s cohort. Which brings us back to the beginning of the cycle. ‘Are we attracting students with appropriate abilities for this course?’ And on it goes ….

In writing these booklets, and running the workshops we have had a lot of fun and we hope that you catch the flavour of this in using them. Stay in touch and give us feedback about your ideas in implementing any of the suggestions. As a community we can learn most from each other.

Caroline Baillie and Leone Burton
Editors
WHY THIS BOOKLET?
More and more students are finding themselves learning ‘at a distance’, even in institutions that are ostensibly single-mode face-to-face (f2f) teaching establishments. So, whether or not we see ourselves as engaged in the business of distance education, all academics need to have a basic understanding of the requirements of distance learners and some idea of how best to support them while they attempt to learn.

WHAT IS HERE?
This booklet is a distillation of the essential elements of distance education and a succinct guide to how to produce effective distance learning materials. It is not a course in developing full-blown distance learning courses. But the underlying rules, tips and tricks are precisely those that go in to the best examples of such courses. Many of them will also benefit f2f learners if applied with imagination.

There is a plethora of excellent guides to the production and presentation of distance learning materials. A number of these are listed at the end and if you are serious about developing distance learning modules, you are strongly recommended to consult them. The best I can hope to do here is to provide a number of aides mémoires and attempt to encapsulate some of the accepted wisdom on distance learning.

If you are hoping to develop a distance learning module for yourself, you would be wise to follow the guidelines provided here. But all such activities are experimental so have a go, enlist the learners in the experiment and see what happens!

This booklet is styled as a short practitioner’s guide with a number of brief activities. First, though, I am going to go over just a few of the key ideas.

DEFINITIONS AND CONCEPTS
‘Open learning’, ‘distance learning’, or ‘open and distance learning’?
Open learners study in their own time and at their own pace (within reason – more on this later). Distance learners are physically and/or temporally remote from each other and their ‘teachers’. So each type of learner has their own needs. Try this:

● How many different ways can you think of connecting distance learners to their ‘learning community’?
Which of these could not be used for open learners without compromising their ‘open-ness’ and why?²

So, you see, open learners need not be distant and distance learning need not be open.

Open and distance learning (ODL) is the term coined to cover the common ground between both types of learner. You need to decide where on each of the scales of openness and distance you want or expect your learners to be.

LEARNER SUPPORT

One of the key questions to address as a provider of ODL is the extent and manner of support you will be offering to learners. All learners need access to some kind of ‘tutor’ to help guide them through the sticky patches. The range of possibilities extends from old-fashioned ‘correspondence tuition’ to regular f2f meetings and includes student/student peer support. Many factors combine to influence what level of support is appropriate, ranging from the geographical distribution of learners to the cost of providing a given level of service. But support there must be if learners are to complete in any numbers.

E-LEARNING AND ON-LINE LEARNING

The advent of widespread domestic access to the Internet has dramatically altered educational providers’ views of ODL. The concept of ‘putting the course notes on the World Wide Web’ and thereby creating a course has, thankfully, now largely been discredited. But there remains the feeling that anyone with a computer is a potential ‘e-learner’ – for which read ‘sales prospect’. I have attempted in this guide to adopt an approach that is independent of the medium of delivery or presentation of the learning materials. The principles of good ODL apply just as much to e-learning as traditional approaches, if not more so. The computer provides a great opportunity to do some things better (or at least differently). But it presents many pitfalls to the obsessive technophile.

Effective ODL

According to Rowntree (1994) among others, to be effective, ODL materials have to be:

- purposeful
- structured
- paced
- engaging

To these, I would add a fourth characteristic:

PURPOSE

Why are you reading this? Stop and write down at least two plausible reasons. (I’m not going to provide any answers to this – the reasons must be your own.)

Was it clear enough at the beginning that your needs were likely to be satisfied by what you would find here? The point is a general one: it’s not enough simply to have a clear sense of purpose when you prepare ODL materials, you also have to communicate that clearly to the learner. So how do we define and communicate purpose?

The most obvious definition of purpose for a learning package is what the learner will be able to do at the end – the vogue term is ‘learning outcomes’ but historically the word ‘objectives’ has also been widely used. The most successful ODL materials have always had clear statements of outcomes couched in terms that are unambiguous. For me, the test of a good learning outcome is whether the learner can point to some specific evidence that they have achieved it. Try this.

How might you demonstrate that you have achieved the following outcome?³
Having completed this module you should be able to understand the significance of van der Waals’ bonding in determining the behaviour of polymers close to their glass transition temperature.3

Of course to demonstrate any learning outcome you have to do something. So why not rewrite the outcome in terms of what the learner should be able to do? It takes a little more thought but can be much more informative for the learner. Linking outcomes to some form of assessment reinforces the learner’s sense of purpose.

Test each of your outcome statements by asking yourself always ‘What evidence could I produce to show that I could now do that?’

Most of us have come to terms with living in an ‘outcomes-focussed’ learning environment. Everything we do has to be circumscribed by one or more sets of learning outcomes; the two principal reference points for the materials science and engineering community are the ‘benchmark statements’ produced by the Quality Assurance Agency (Quality Assurance Agency, 2000 and 2002) and the ‘output standards’ under development by the Engineering Professors’ Council (Engineering Professors Council, 2001). It takes a little creativity to turn a benchmark statement into a learning outcome statement. But a well-constrained learning module lends itself quite easily to such descriptions. I recommend the following approach:

1. trawl through the appropriate benchmark statements for each of the levels of attainment and decide which statements apply to your module and at what level;

2. collect together the statements that apply under appropriate headings (note that the Engineering benchmark statements are not categorized in exactly the same way as those for Materials, so if you choose to use statements from both subjects you will need to invent a compromise);

3. particularize each statement to your module by adding information from the module.

For example, suppose you were planning a short ODL module on corrosion at a relatively advanced level (assuming some prior knowledge of the subject). The relevant benchmark statements work as follows:

The benchmark statements for Materials (Quality Assurance Agency, 2002) suggest under ‘Materials related knowledge and skills’ that:

… materials graduates will have … some familiarity with relevant concepts associated with … degradation/durability of materials – effect of liquid and gaseous environments on the performance of different material types.

Given the level of the module, you might be pitching the outcomes at ‘Attainment level B’ according to the benchmarking document, which states that:

New knowledge is readily acquired … Routine calculations, explanations, interpretations and analysis are executed accurately. Understanding of relevant facts and techniques is good.

The relevant benchmark statement for Engineering (Quality Assurance Agency, 2000) is to be found under the heading of ‘Knowledge and understanding’ in the ‘Design’ category. At a ‘good’ attainment level, graduates are expected to have:

knowledge and understanding of the characteristics of engineering materials and components.

Now write out what you think would be an appropriate learning outcome for this module on corrosion,
recognizing the benchmarks statements for both materials and engineering. You might need to leave some gaps in the outcome statement to take account of the actual content of the module.4

Once you have a set of learning outcomes, you need to ensure that the module itself adequately supports those outcomes and is designed in such a way that learners collect evidence that they have achieved them as they study.

STRUCTURE

The structure of a learning module is of paramount importance in maintaining a learner’s interest. Just as with purpose, the structure must be clear to the learners and this will allow them to exert some control over how they learn. Distance learners can feel extremely isolated and a feeling of control is a great boost to self confidence.

There are a number of ways of structuring ODL materials, each of which can be equally effective but each has its distinct advantages and disadvantages. The following brief list encompasses most options:

- teaching ‘narratives’
- textbooks + commentary
- action guides + resources

Think always in terms of a narrative. People find it easiest to follow something that has a beginning, a middle and an end – something akin to a ‘learning journey’. The narrative does not have to reside explicitly within the learning resources. It can be constructed by the learner themselves, under your guidance or in collaboration with other learners. The choice of structure you adopt is crucial to deciding how to provide a narrative but a random collection of ‘learning objectives’ is not likely to motivate the learner.

In the case of teaching narratives, you are going to have to construct the learning materials effectively from scratch. You should not underestimate the commitment this requires and the time and trouble you will have to take.

Continuing with the subject of corrosion, one way of structuring a linear teaching narrative might be (don’t take this too literally):

1. **Introduction** – explaining the importance of understanding corrosion by means of a few examples and setting the limits to what the module will cover.

2. **The physical chemistry of corrosion** – introducing/revising the thermodynamic and kinetic factors driving corrosion.

3. **Materials and corrosion** – looking at how materials interact chemically with their environments resulting in corrosion.

4. **Case studies in corrosion** – showing how the information provided in the module so far can be used to explain and avoid problems of corrosion in the real world.
Having written such a text, you must ensure that it is reviewed for accuracy and edited for sense and style by other colleagues. Of course this will add time to its production but will more than repay the time cost in increased effectiveness.

An alternative way of providing such a learning package is to use existing published texts to cover the same ground. You could keep the same order of material that I have suggested above but this time provide a specified list of readings under each of the headings (with the possible exception of the introduction). Such readings, however, are likely to be crucially deficient in many of the key attributes of ODL materials that I have listed in previous and subsequent sections. So you can provide them in a narrative commentary. This is your opportunity, of course, to criticize the established view on the subject. Mostly, though, you need to think about how to assist the learner actually to learn from the given texts by incorporating appropriate interaction.

A different approach is to turn the narrative on its head. Given that effective learning involves doing things, a good way of generating learner-focussed learning materials is to set the learners one or more tasks and guide them to the sources of information they need to complete the task. Here the learner will be providing much of the narrative for themselves and this approach requires a significantly higher level of sophistication from both you and the learner.

Such a learning module could consist of:

1. one or more case histories – describing situations where corrosion caused a problem;
2. a report outline – that learners are expected to complete about each case history and submit for assessment;
3. a reading list – containing all the key information;
4. a discussion forum – where learners can work together to identify and pursue the key aspects of the problem, effectively constructing their own narrative.

This last approach highlights the fact that the structure you adopt can depend as much on the abilities and stage of development of the learners as on what you are hoping to achieve. So you might consider a progression from purpose-written narratives at Level 1 to more of a resource-based learning approach at Level 3.

Race (1992) is worth consulting for more ideas and suggestions.

**PACING**

Have you read to this point without stopping? Or did you stop at some point and then start again some time later? Distance learners need to know how much time to spend on a given learning package, when it is permissible to take a break in their studies and when they need to pick them up again.

I mentioned earlier that open learners study at their own pace. Those experienced in ODL will know, though, that completely open-ended study is rarely effective. Most learners will lose momentum at some stage and, without a truly pressing need to continue, will rarely pick things up again. Mostly the pressing need is some form of assessment, so here we have one of the main techniques for pacing learners – deadlines!

Assessment deadlines can be published in a study calendar which also provides you with an opportunity to suggest the overall pace of study you expect.
Learning materials at a distance

from the learner. The pace itself should be a balance between what you think is reasonable to expect from the learner (given that they are studying at a distance and in conjunction with other activities) and how the particular learning module ties in with other modules in the programme.

**Interaction**, both learner-to-learner and learner-to-tutor, is another powerful method of ensuring learners maintain an appropriate pace, and judicious intervention by tutors can help motivate and encourage learners to keep going. The role of the tutor in distance learning is a subject in its own right and I recommend you consult one of the sources listed under ‘Further reading’ if you wish to pursue this further.

**ENGAGEMENT**

Do you want to know what comes next? Why? Is it really that important to you or have I managed to excite your interest despite more pressing demands on your time?

Look back over the previous section of this booklet and identify at least three devices I have used to engage your interest. Which do you think is most important and why?

There really is little point producing learning materials that don’t engage the learners in the process of learning. As academics we tend to present information in just about as dull a fashion as is imaginable. But think about it from a learner’s perspective. Would they rather be working through your stuff or doing the ironing? I can think of many occasions when the ironing seemed infinitely preferable. And, unlike the captive audience in a lecture theatre, there is actually nothing stopping the distance learner getting up and walking away when they lose interest. So you have to put some serious thought into engaging and motivating the learner.

Some of the rules of engagement in distance learning are not so obvious so here are a few notes that you might find helpful.

- You are addressing the learner as an individual so do so directly. You should be ‘I’, the learner should be ‘you’ (singular). The pronoun ‘we’ should be reserved exclusively for those occasions where you want to include both you and the learner.

- You should avoid the passive wherever possible as it distances the learner from what is going on. You can generally do so without resorting to the impersonal ‘we’ by making what you are discussing the subject of the sentence.

- Use humour sparingly.

- Think very carefully about glib phrases such as ‘obviously’, ‘as you know’, ‘simply’ and so forth. It is salutary to read through what you have written, identify such phrases and ask what the reaction of a learner would be to whom things were not obvious, already known or plainly simple. Upsetting or confusing learners is a remarkably simple way to alienate them.

- Give some thought to the diversity of your learners. This should not be a manifestation of political correctness. But they won’t all share your cultural heritage so you should be careful of references which include assumptions about gender, race, language, history and so on. If the learner misses the point for these reasons you might just as well not have written it.

**A NOTE ABOUT MEDIA**

As I stated earlier I’ve used an approach that has avoided discussing the medium in which the learning module might be presented. The fashion over the last decade in
ODL has been a steady move towards electronic media (stand-alone and networked). But as the developer of an ODL module you should think carefully about the appropriateness of the media you intend to use.

Write down two advantages and two disadvantages to presenting study materials on a computer screen rather than sending learners traditional materials such as print and cassette.

The actual choice of the mix of media should be led by a combination of the learner’s needs and your own. The effectiveness of the learning experience hinges more on aspects of purpose, structure, pacing and engagement than on precisely which media you choose.

Any discussion of media would be incomplete without some reference to current legislation on disability. The best advice on this must be to consult the experts as to what is practicable at as early a stage as possible. I have included a checklist point on this in the template that follows.

A TEMPLATE FOR AN ODL MODULE

Finally I offer up a template for you to use to focus your thinking about the ODL module you plan to develop. If you allocate time to filling in such a template, not only will you be well on your way to finalizing the module but you will also have a document you can discuss with both colleagues and potential learners.

ACKNOWLEDGEMENTS

The guidelines presented in this booklet formed the basis of a workshop hosted by The Open University, Department of Materials Engineering on behalf of the UK Centre for Materials Education in October 2001. I should like to extend my gratitude to David Baume who, as then Director of the Centre for Higher Education Practice (CeHEP), made a major contribution to that workshop and contributed to the material presented here.
REFERENCES AND FURTHER INFORMATION

REFERENCES

Engineering Professors Council (2001)

Quality Assurance Agency (2000)
Engineering benchmark statements, http://www.qaa.ac.uk/crntwork/benchmark/benchmarking.htm

Quality Assurance Agency (2002)

BOOKS AND GUIDES

The Department for Education and Skills (http://www.dfes.gov.uk) offers a range of immensely informative Guides for Managers, Practitioners and Researchers in open and distance learning, commissioned by their Lifelong Learning and Technologies Division. These include many well-documented case studies.

There are a number of good books available to help with the job of developing ODL materials and supporting distance learners. In particular:


Race, Phil, (1992) 53 interesting ways to write open learning materials, Bristol: Technical and Educational Services


The University of Plymouth, Department of Telematics maintains a website of Distance education resources, lists and contacts, http://www.fae.plym.ac.uk/tele/resources.html

COURSES

The National Extension College (http://www.nec.ac.uk) offers courses in online tutoring.

The Open University (http://www.open.ac.uk) offers postgraduate courses in Open and Distance Education.

ORGANIZATIONS

BAOL, The British Association for Open Learning (http://www.baol.co.uk) is a forum for UK providers of ODL, mostly from the private sector.

EADL, The European Association for Distance Learning (http://www.eadl.org) offers a Europe-wide forum for ODL providers.

EADTU, The European Association of Distance Teaching Universities (http://www.eadtu.nl) concentrates on HE providers in the public sector.

ICDL, The International Centre for Distance Learning (http://www.icdl.open.ac.uk) maintains a vast database of information about all aspects of ODL.

ICDE, The International Council for Open and Distance Education (http://www.icde.org) is a global organization supporting ODL providers that sponsors a biennial World
Conference which attracts thousands of delegates from many different countries. They have just (March 2003) launched an International Standards Agency to accredit courses and programmes worldwide.

ODL QC (http://www.odlqc.org.uk) is an accrediting organization for ODL providers, mostly below HE level and in the private sector. Their Quality Standards (http://www.odlqc.org.uk/standard.htm) are a model of their kind.

FOOTNOTES

1. This is what I would suggest, in no particular order: telephone; email; correspondence; webchat; computer-mediated conference; video-conference; audio cassette; video cassette.

2. The synchronous methods – telephone, webchat, video-conference – are unsuitable as they tie the learner to a time and place. Only the asynchronous communication methods could be used for true open learners.

3. My suggestion is that you would have to describe the nature of van der Waals' bonding and its relationship to primary bonding, and explain how the thermal energy in the system can be sufficient to overcome the effects of vdW forces above Tg.

4. I would propose something like this:

Can describe and explain the effects of [specified types of corrosive environments] on [particular types of materials] and can use the associated knowledge to suggest and justify improvements to given designs in order to mitigate or avoid problems associated with materials degradation. It’s quite wordy so this one outcome could well be broken down into several components.

5. I think I have:

1. engaged you in a ‘conversation’;
2. given you things to do;
3. provided a clear structure;
4. set out some outcomes that are relevant to your needs.

In my opinion, this is the order of importance of these four devices. If learners are involved in the process, everything else follows on.

6. Presenting materials ‘electronically’ can:

1. virtually eliminate the delays inherent in printing and delivery of conventional materials;
2. provide built-in ‘multimedia’ capabilities where text, audio, video, WWW etc can be integrated almost seamlessly into a single ‘document’;
3. provide effective updating routes for frequently-changing information or to deal with errors etc.

They can also:

1. tie learners to a computer, which is at best an awkward thing to carry around compared to a book or an audio cassette/CD player;
2. go wrong with disastrous consequences for the distance learner;
3. transfer the costs of printing to the learner.
Learning materials science and engineering at a distance
Other Booklets In the Series:

- Attracting Materials Students – Cheryl Anderson
- Environmental Materials – Cris Arnold
- Teaching Materials Using Case Studies – Claire Davis and Elizabeth Wilcock
- Developing Professional Skills – John Wilcox
- Assessing Materials Students – Lewis Elton
- Learning Materials at a Distance – Mark Endean
- Materials for Engineers – Mike Bramhall
- Tutoring Materials – Adam Mannis and Shanaka Katuwawala
- Learning Materials in a Problem Based Course – James Busfield and Ton Peijs
- Materials Chemistry – Stephen Skinner
- Teaching Materials Lab Classes – Caroline Baillie
- Evaluating a Materials Course – Ivan Moore
Learning Materials at a Distance

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